AD-A105 023 KIMBALL (L ROBERT) AND ASSOCIATES EBENSBURG PA F/G 13/13
NATIONAL DAM SAFETY PROGRAM. LAKE LACAWANNA DAM (MO 30280), MIS--ETC(U)
FEB 80 R J KIMBALL, J T HOCKENSMITH DACW43-79-C-0034

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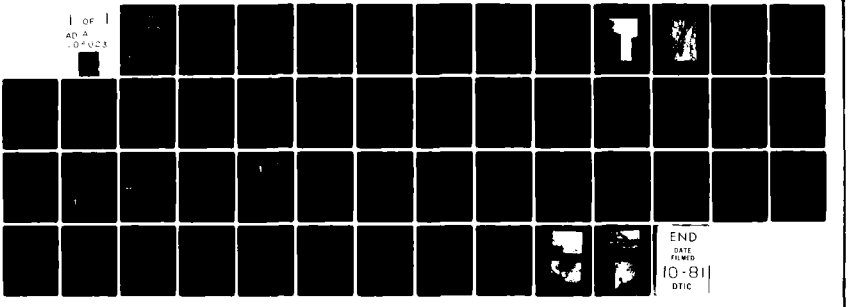

MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

LEVEL II

1

LAKE LACAWANNA DAM

ST. FRANCOIS COUNTY, MISSOURI

MO 30280

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
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St. Louis District

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PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

FEBRUARY 1980

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

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SUBJECT: Lake Lacawanna Dam Phase I Inspection Report

This report present the results of field inspection and evaluation of the Lake Lacawanna Dam (MO. 30280).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass a 10-year frequency flood without overtopping of the dam. The spillway is, therefore, considered to be unusually small and seriously inadequate..

b. Overtopping could result in dam failure.

c. Dam failure significantly increases the hazard to life and property downstream.

Submitted by: SIGNED — 14 APR 1980
Chief, Engineering Division — Date

Approved by: SIGNED — 14 APR 1980
Colonel, CE, District Engineer — Date

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in detemining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

NAME OF DAM	Lake Lacawanna
STATE LOCATED	Missouri
COUNTY LOCATED	St. Francois
STREAM	West Fork of Plattin Creek
DATE OF INSPECTION	September 5, 1979

Lake Lacawanna Dam was inspected using the "Recommended Guildelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines are considered to represent a consensus of the engineering profession.

Based on the criteria in the guidelines, the dam is in the high-hazard potential classification, which means that loss of life and appreciable property loss could occur in the event of failure of the dam. The dam is in the small size classification since it is greater than 25 feet high, but less than 40 feet high. The estimated damage zone extends approximately six miles downstream of the dam. Within this damage zone are approximately twenty-three dwellings and Laguna Palma Dam.

Based on the downstream affected area the Spillway Design Flood for this dam is the PMF (Probable Maximum Flood). The spillway is capable of controlling approximately 4% of the PMF without overtopping the embankment. In addition, the spillway cannot control the 100 year storm or the 10 year storm. The spillway is considered seriously inadequate.

Deficiencies visually observed for Lake Lacawanna were no riprap on the upstream slope, severe erosion on the downstream slope and at the embankment/abutment contact, seepage exiting beyond the toe of the dam, and vegetation on the embankment slopes and in the spillways. There is no warning system in effect or a safety inspection program. Stability and seepage analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" are not available which is considered a deficiency. These deficiencies should be remedied at the direction of a professional engineer knowledgeable in the design and construction of earthfill dams.

R. JEFFREY KIMBALL, P.E.
L. Robert Kimball & Associates
Vice President, Earth Sciences

JAMES T. HOCKENSMITH
L. Robert Kimball & Associates
Geologist

Photograph No. 1. Overview of upstream slope.

Photograph No. 2. Overview of downstream slope.

TABLE OF CONTENTS

LIST OF APPENDICES

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LAKE LACAWANNA DAM - ID NO. 30280

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of Lake Lacawanna Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general conditon of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. Lake Lacawanna Dam is an earthfill dam approximately 26 feet high and 464 feet long. The downstream slope of the embankment is 2.5H:1V and is covered with a growth of vegetation consisting of high grasses and small trees. The upstream slope is approximately 1H:1V and covered with a heavy growth of high grasses and trees. The upstream slope has no riprap. The crest width is 10 feet and is also covered with grasses and small trees.

A small open cut spillway channel is provided on each abutment. The spillway exit channels flow down the abutment at the embankment/abutment contact.

No principal spillway or outlet pipes are provided at Lake Lacawanna Dam.

b. Location. Lake Lacawanna Dam is located approximately 3.8 miles southeast of Valles Mines, Missouri, on the West Fork of Plattin Creek. The dam can be located (Section 11, Township 38 North, Range 5 East) on the Halifax, Missouri 7.5 minute U.S.G.S. quadrangle.

c. Size Classification. Lake Lacawanna Dam is a small size structure (26 feet high, 132 acre-feet).

d. Hazard Classification. Lake Lacawanna is a high hazard dam. Downstream conditions indicate that loss of life is probable should failure of the dam occur. The estimated damage zone downstream of the dam is approximately six miles. Within this damage zone approximately 23 dwellings and Laguna Palma Dam are located.

e. Ownership. Lake Lacawanna Dam is owned by MWR Enterprises, Inc. Correspondence should be addressed to:

Mr. John C. Wright
MWR Enterprises, Inc.
P.O. Box 307
Farmington, Missouri 63640
314-756-6656

MWR Enterprises, Inc. ownes 92 of the 236 lots at the lake site. These lots were acquired approximately 1 year ago by a purchase at a foreclosure sale. The property owners association of Lake Lacawanna have sued MWR Enterprises, Inc. to obtain responsibility for management and upkeep of the properties which include the dam and roads. The Lake Lacawanna Association is represented by Mr. Tyree C. Derrick, 1217 Mississippi Valley Building, 506 Olive, St. Louis, Missouri 63101.

f. Purpose of Dam. Lake Lacawanna is used for recreation.

g. Design and Construction History. Based on discussions with Mr. Wright of MWR Enterprises, no design or construction history is available on the dam. Mr. Wright reported that the dam was constructed by a now defunct corporation, called Extos, Inc. approximately 25 years ago. No design drawings, reports, or construction history was available through any other sources.

h. Normal Operating Procedures. No operating records exist. The left spillway is used to maintain a normal reservoir level. This left spillway is several feet lower than the right spillway.

1.3 PERTINENT DATA

a. Drainage Area.	2.8 square miles U.S.G.S. quadrangle

b. Discharge at Damsite (cfs).

(1)	Maximum known flood at dam site	Unknown
(2)	Spillway capacity at top of dam	686
(3)	Drainlines	None

c. Elevation (feet) - field survey based on spillway elevation 682 shown on U.S.G.S. quadrangle.

(1)	Top of dam	685.8
(2)	Left spillway crest	681.5
(3)	Right spillway crest	684.4
(4)	Normal pool	682.0
(5)	Maximum pool (PMF)	691.8
(6)	Tailwater on day of inspection	None
(7)	Streambed at centerline of dam	660.6

d. Reservoir (feet).

(1)	Length of maximum pool	3000
(2)	Length of normal pool	1900

e. Storage (acre-feet).

(1)	Top of dam	159
(2)	Spillway crest	91
(3)	Normal pool	91
(4)	Maximum pool (PMF)	288

f. Reservoir Surface (acres).

(1)	Top of dam	17.5
(2)	Spillway crest	14
(3)	Normal pool	14
(4)	Maximum pool (PMF)	23

g. Dam.

(1)	Type	Earth embankment
(2)	Length	464 feet
(3)	Height	26 feet
(4)	Top width	10 feet
(5)	Side slopes	Upstream - 1H:1V Downstream - 2.5H:1V
(6)	Zoning	Unknown
(7)	Grout curtain	Unknown
(8)	Cutoff	Unknown

h. Spillway.

(1) Type	Earth - trapezoidal
(2) Length (bottom)	
Left spillway	16 feet
Right spillway	13 feet
(3) Crest elevation	
Left spillway	681.5 feet
Right spillway	684.4 feet
(4) Upstream channel	Lake
(5) Downstream channel	West Fork of Plattin Creek
(6) Weir shape (both spillways)	Trapezoidal

j. Drawdown Facilities. None

SECTION 2 - ENGINEERING DATA

2.1 DESIGN. No design drawings, reports or data are known to exist.

2.2 CONSTRUCTION. Based on interviews with the owner it is reported that the dam was constructed approximately 25 years ago by the Extos Corporation. No information exists on construction of the dam.

2.3 OPERATION. No operating records exist.

2.4 EVALUATION.

a. Availability. There are no engineering data available.

b. Adequacy. The field surveys and visual inspection presented herein are considered adequate to support the conclusion of this report. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspections of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity. Not applicable.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. The onsite inspection of Lake Lacawanna Dam was conducted by personnel of L. Robert Kimball and Associates on September 5, 1979. The inspection team consisted of a hydrologist, structural/soils engineer and a geologist. The inspection consisted of:

1. Visual inspection of the retaining structure, abutments, and toe.
2. Examination of the spillway facilities, exposed portions of any outlet works, and other appurtenant works.
3. Observations affecting the runoff potential of the drainage basin.

b. Project Geology. The bedrock underlying Lake Lacawanna Dam consists primarily of the Roubidoux formation which is part of the Canadian Series of the Ordovician System. The Gasconade formation underlies the Roubidoux formation.

The Roubidoux formation contains sandstone, dolomitic sandstone and cherty dolomite. Except in the central part of the state, the sandstone accounts for little more than 10% of the formation, the remainder consisting mostly of cherty dolomite. The dolomite is light gray to brown, finely crystalline, and thinly to thickly bedded. The Roubidoux formation ranges in thickness from 100 to 250 feet, but is probably thinner here, since much of it has been eroded away.

The Gasconade is primarly a light brownish-gray cherty dolomite in this area. The lower part of the dolomite is coarsely crystalline and chert often makes up more than 50% of the volume of the rock. The upper part of the dolomite, which is present around Lake Lacawanna, is finely crystalline and contains much smaller amounts of chert. The chert may be white and porcelain-like or with brown and gray bands. Many of the nearly vertical cliffs in the central Ozarks are formed by the Gasconade. Springs and caves are also common in this formation, which may be from 300 to 700 feet thick.

Only one rock outcrop was observed during the inspection. This was at the left abutment of the dam in the spillway exit channel and consisted of cherty dolomite. This may be either the Upper Gasconade or the lower Roubidoux. The rock was slightly weathered and exhibited some jointing while the beds were of moderate thickness. Solution cavities are often found in these rock types, but no evidence of karst terrain was

observed in the vicinity. It is difficult to distinguish any more detailed information on the basis of one brief inspection with only one outcrop. The published literature contains little else of value concerning these two formations.

Structural features in the vicinity of Lake Lacawanna include the Plattin Creek anticline. The axis plunges gently northwards. The eastern limb is slightly steeper, but both limbs are reported as gentle (no dips are given). The Rugley School fault block and fault is another structural feature. A component of the Valles Mines - Vineland fault zone which is in turn, a part of the St.Genevieve fault system, the Rugley school fault is the largest of a series of faults bounding the Rugley school fault block. This is an untilted wedge of sediment marked by faults on the northwest, north and northeast. To the south, however, it merges with the Farmington anticline. The Rugley School fault brings the Davis Shale into contact with Gasconade Dolomite while the other faults have small displacements of only about 75 feet. Some seismic activity is noted in this part of the state.

c. Dam and Spillway. The visual inspection of the dam indicated that the structure was in fair condition. From a brief survey conducted during the inspection, it was noted that a low spot is located on the crest of the dam. This low spot has a surface elevation of 685.8. The downstream slope was measured at 2.5H:1V with the upstream slope 1H:1V. The crest width is 10 feet. The upstream slope, downstream slope and crest are both covered with heavy grasses and small trees. No riprap is provided on the upstream slope. Several areas of deep erosion were noted on the downstream slope of the embankment. These erosion gullies are up to 4 feet deep. The embankment consists of a clayey sand material which is highly erosive. One seepage area was noted beyond the toe of the dam (See Figure 2). The seepage flowing from this area was estimated at one to two gallons per minute.

An open cut spillway channel is located on each abutment. The left spillway is approximately 5 feet deep and controls the normal water surface of the reservoir. The right spillway is approximately 1.5 feet deep. The left spillway exit channel flows down the left abutment to beyond the toe of dam. Some of the water flowing down the exit channel is breaking out and creating erosion and a scour hole adjacent to the embankment of the dam. The right spillway exit channel is formed by a deep erosion gully along the embankment abutment contact. Both spillways have small trees blocking flow.

d. Drainlines. No drainlines or facilities to drawdown or control the reservoir level were noted during the inspection.

e. Reservoir Area. No pertinent problems were noted in the reservoir area. The watershed is moderately steep and wooded.

f. Downstream Channel. West Fork downstream of Lake Lacawanna Dam is moderately flat with a moderately wide flood plain. Approximately 2 miles downstream of Lake Lacawanna is Laguna Palma Dam.

3.2 EVALUATION. The earth embankment section of the dam is in fair condition and in need of maintenance. The erosion gullies located on the downstream slope of the dam should be repaired. In addition, the trees on the embankment slopes should be removed. The spillway channels should be repaired to eliminate the erosion along the embankment/abutment contacts and to direct water away from the embankment. The seepage exiting from the reservoir should be monitored on a regular basis. With removal of the trees on the upstream slope and because of the erosive nature of the soils, riprap should be provided on the upstream slope.

Complete evaluation of the structure cannot be made without a detailed stability and seepage analysis.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES. The reservoir is maintained at the left spillway crest. No facilities are available to drawdown or regulate the pool level.

4.2 MAINTENANCE OF DAM. No maintenance of the dam is conducted.

4.3 MAINTENANCE OF OPERATING FACILITIES. There are no operating facilities to maintain.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT. Upon checking with the owner, the inspection team is unaware of any warning system in effect.

4.5 EVALUATION. Maintenance of the dam and operating facilities are considered poor. There is no warning system in effect to warn downstream residences of large spillway discharges or failure of the dam.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. There are no hydraulic or hydrological design data available as discussed in Section 2.

b. Experience Data. The drainage area was developed using the U.S.G.S. quadrangle sheet. The lake surface area was determined by planimetering the quadrangle sheet. Surface area - elevations were determined by planimetering various contour lines within the drainage area on the U.S.G.S. quadrangle sheets. The spillway and dam layout was made from surveys conducted from the inspection. There is no history of the dam being overtopped. However, the location of the severe erosion gullies on the downstream slope corresponds to the low point on the embankment crest. This observation may indicate that the dam has been overtopped.

c. Visual Observations. The left spillway controls the normal flow from the reservoir. The left spillway is approximately 16 feet wide and has a crest elevation of 681.5. The right spillway is approximately 13 feet wide with a crest elevation of 684.4. The low spot on the top of dam is at elevation 658.8. This low point was used as a crest elevation in the overtopping analysis. The drainage area is wooded with moderate slopes. Hydrologic soil group B was used in the hydrologic analyses.

d. Overtopping Potential. Overtopping potential was investigated through the development of the probable maximum flood (PMF) for the watershed and the subsequent routing of the PMF and fractions of the PMF through the reservoir and spillway.

The Corps of Engineers, St. Louis District, has directed that the HEC-1 Dam Safety Version systemized computer program be utilized. The program was prepared by the Hydraulic Engineering Center (HEC) U.S. Army Corp of Engineers, Davis, California, July, 1978. The major methodologies or key input data for this program are discussed in Appendix B.

Complete summary sheets for the computer output are presented in Appendix B. To facilitate review, the major results of the overtopping analysis are presented below:

Peak inflow	22,200 cfs
Spillway capacity	670 cfs

Ratio of PMF	Maximum Reservoir Water Surface	Maximum Depth over Dam (embankment)	Maximum Outflow, cfs	Duration of over-topping, hours
.04	685.29	0.00	518	0.00
.10	687.41	1.61	1966	2.50
.50	690.08	4.28	10885	7.17
1.00	692.17	6.37	21959	13.33

The Corps of Engineers Spillway Design Flood for a high hazard-small dam is 1/2 PMF to the PMF. Based on the downstream hazard exposure, the Spillway Design Flood for this dam has been selected to be the PMF. The spillway is capable of controlling only approximately 4% of the PMF without overtopping the embankment. Overtopping the embankment for an extended period of time or with depth will cause failure of the dam.

Because of the low spillway capacity the 10 year storm was routed through the reservoir. Based on perimeters provided by the St. Louis District, Corps of Engineers, the spillway cannot control the 10 year storm. Despite no record of reservoir water levels and no history that the dam has overtopped, there is evidence that the dam may have been overtopped (See Section 5.1b). Thus, the spillway is not capable of controlling the 10 year or 100 year storms. The spillway is considered seriously inadequate. In the event of an overtopping the embankment, which consists of a clayey sand material, would quickly erode.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. The earth embankment appeared to be in fair condition. Severe erosion is occurring on portions of the downstream slope. Some of these erosion gullies are up to 4 feet deep. In addition, discharges from the spillways have caused erosion on the embankment/abutment contact. One seepage zone was noted during the inspection beyond the toe of the dam.

b. Design and Construction Data. No design or construction data is available on the dam. Stability and seepage analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspections of Dams" were not available, which is considered a deficiency..

c. Operating Records. No operating records are kept on ths structure.

d. Post Construction Changes. No post-construction changes are known for this structure.

e. Seismic Stability. The dam is lcoated in seismic zone 2 to which the guidelines assign a "moderate" damage potential. No seismic stability analysis has been conducted.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. The visual observations, review of available data and hydrologic calculations indicate that Lake Lacawanna Dam's spillway is seriously inadequate. The spillway is capable of controlling approximately 4% of the PMF without overtopping the embankment. In addition, the spillway and reservoir cannot control the 100 year storm or the 10 year storm.

The earth embankment portion of the dam appeared to be in fair condition. Serious erosion and a seepage zone was noted during the inspection. Trees are growing on all portions of the embankment slopes. No means of regulating or drawing down the reservoir is provided. Stability and seepage analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspections of Dams" were not available, which is considered a deficiency. With removal of the trees on the upstream slope and because of the erosive nature of the soils, riprap should be provided on the upstream slope.

b. Adequacy of Information. Complete assessment of the structural stability of the structure cannot be made because of the limited design data and construction data. Stability and seepage analyses comparable to the requirement of the "Recommended Guidelines for Safety Inspections of Dams" were not available, which is considered a deficiency.

c. Urgency. The deficiencies described herein are serious and corrective actions listed in 7.2.b should be initiated on a high priority basis. Special note should be made of items in paragraph 7.2.a and these recommendations should be pursued immediately.

d. Need for Phase II. In order to accomplish some of the recommendations/remedial measures outlined below, further investigations will be required. However, a Phase II investigation is not required.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

a. Alternatives. A detailed hydraulic and hydrology study should be conducted by a registered professional engineer knowledgeable in dam design to increase the spillway capacity. The study should begin immediately and remedial modifications begun immediately after the study is complete.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended:

1. Clear trees and brush selectively from the slopes of the dam and spillway at the direction of an engineer familiar with dam design and construction. After the slopes are cleared an inspection of the downstream slope should be made. Slope clearing can result in the development of problem seepage or erosion and should be planned and executed with caution.

2. Seepage and stability analysis should be performed by a professional engineer experienced in teh design and construction of dams.

3. The erosion on the embankment slopes should be repaired.

4. Protection should be provided on the embankment abutment contact from erosion due to discharges from the spillways.

5. Riprap should be provided on the upstream slope of the dam.

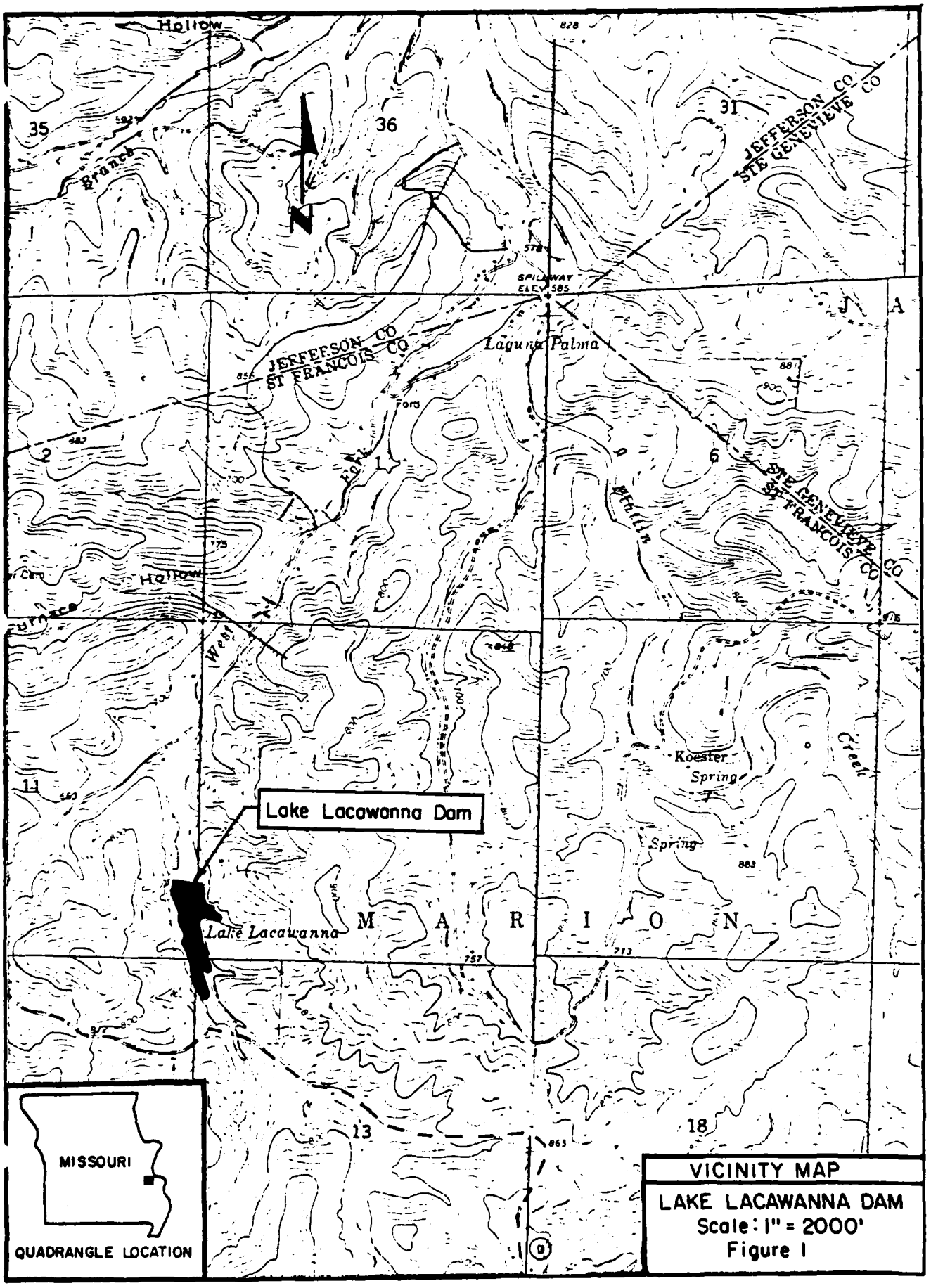
6. The seepage exiting from beyond the toe of dam should be monitored at regular intervals.

7. A means of draining the lake and regulating the reservoir surface should be provided.

8. Institute a formal inspection program to be conducted at regular intervals by a registered professional engineer knowledgeable in earth dams.

9. Institute a formal warning system to warn downstream residences of high spillway discharges or failure of the dam.

DRAWINGS



VICINITY MAP

LAKE LACAWANNA DAM
Scale: 1" = 2000'
Figure 1

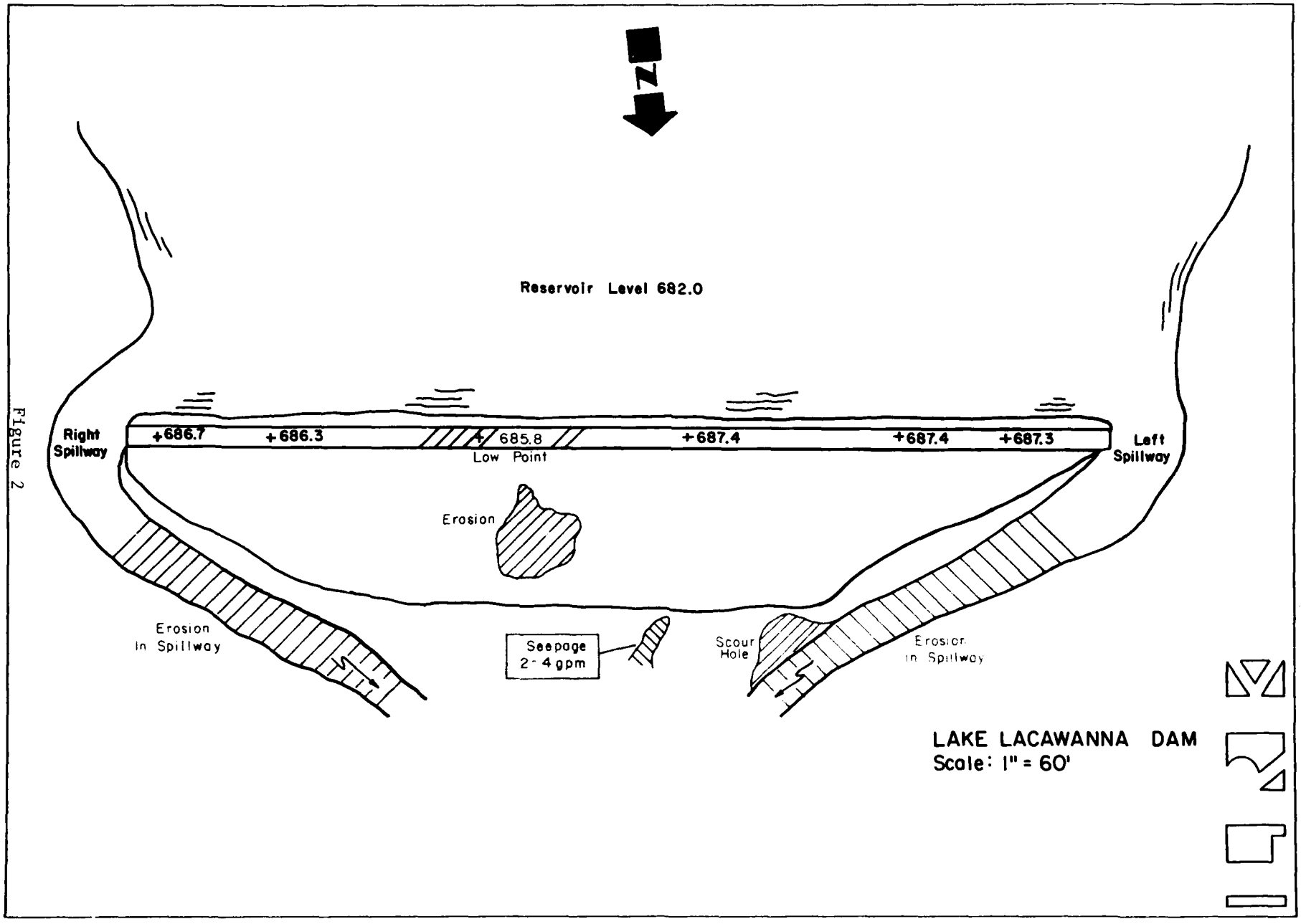
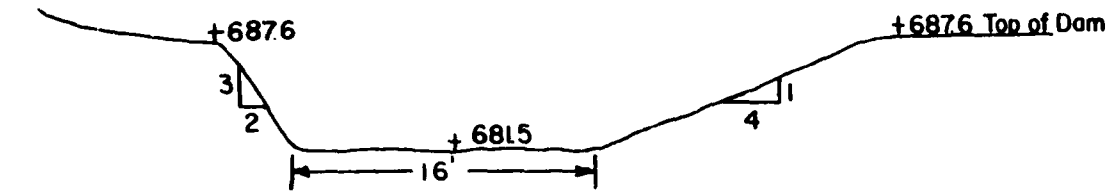
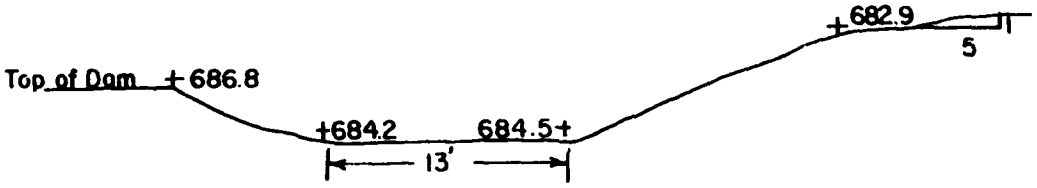

N
Reservoir Level 682.0
Right Spillway
+686.7
+686.3
685.8
Low Point
+687.4
+687.4
+687.3
Left Spillway
Erosion
Erosion in Spillway
Seepage 2-4 gpm
Scour Hole
Erosion in Spillway
LAKE LACAWANNA DAM
Scale: 1" = 60'

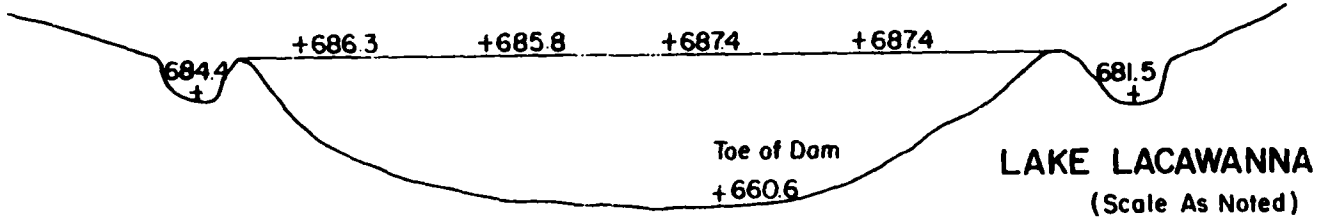
Figure 2



LEFT SPILLWAY SECTION
LOOKING DOWNSTREAM
(Scale 1" = 10')



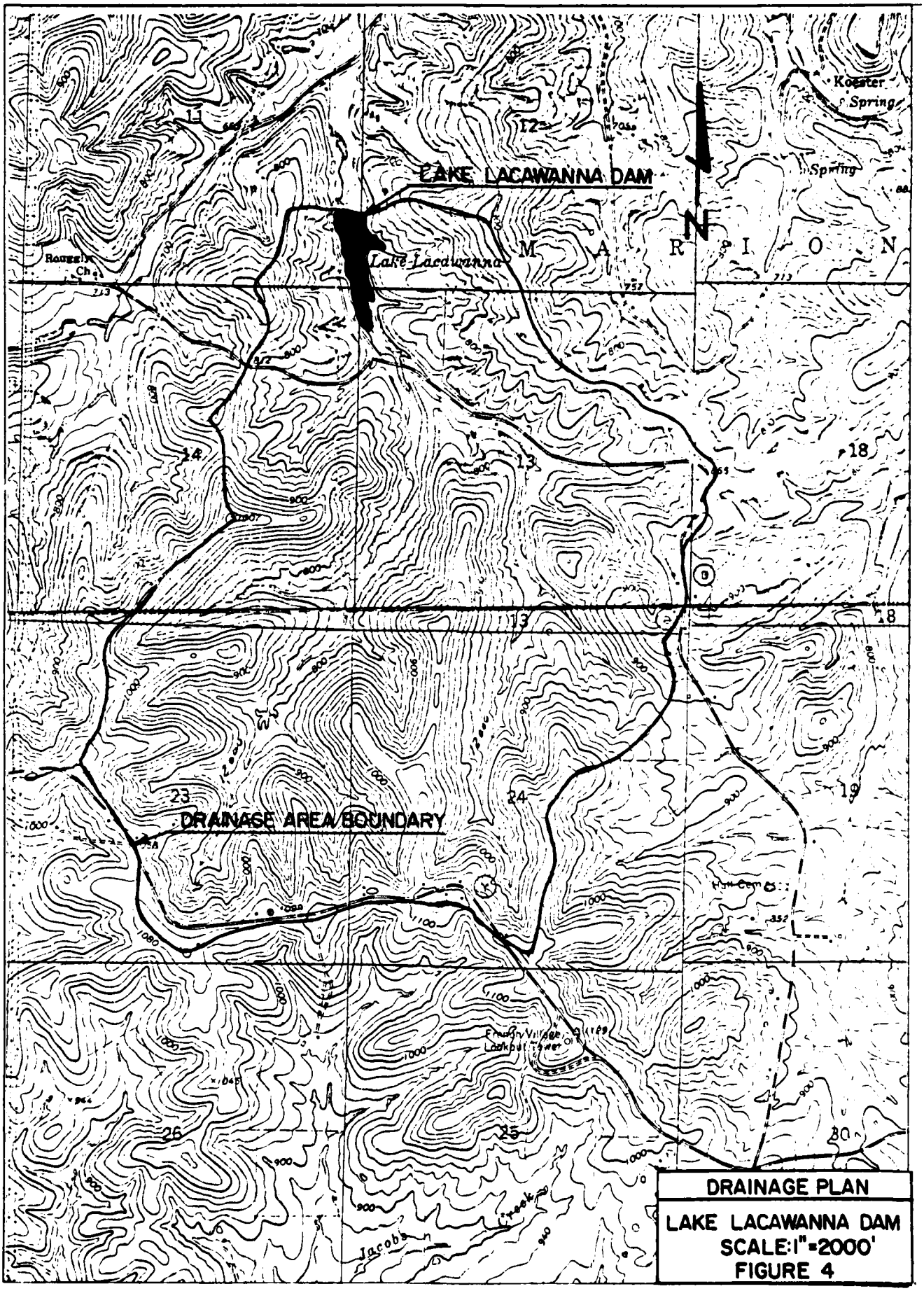
RIGHT SPILLWAY SECTION
LOOKING DOWNSTREAM
(Scale 1" = 10')



LAKE LACAWANNA DAM
(Scale As Noted)

PROFILE OF DAM LOOKING UPSTREAM
(Scale 1" = 100' Horiz. and 1" = 20' Vert.)

Figure 3


LAKE LACAWANNA DAM
Lake Lacawanna
DRAINAGE AREA BOUNDARY
N
M A R I O N
Koester Spring
Spring
Rangeley Ch.
Jacobs
DRAINAGE PLAN
LAKE LACAWANNA DAM
SCALE: 1" = 2000'
FIGURE 4

HYDROLOGY AND HYDRAULICS

APPENDIX B

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for a reservoir routing. The Probable Maximum Precipitation is derived and determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors have not been applied. A 48 hour storm duration is assumed with total depth distributed over 6 hour periods in accordance with procedures outlined in EM 1110-2-1411 (SPF Determination). The maximum 6 hour rainfall period is then distributed to hourly increments by the same criteria. Within-the-hour distribution is based upon NOAA Technical Memorandum NWS HYDRO-35. The non-peak 6 hour rainfall periods are distributed uniformly. All distributed values are arranged in a critical sequence by the SPF criteria. The final inflow hydrograph is produced by deduction of infiltration losses appropriate to the soil, land use, and antecedent moisture conditions.

The reservoir routing is accomplished by using Modified Puls routing techniques wherein the flood hydrograph is routed through lake storage. Hydraulic capacities of the outlet works, spillways, and crest of dam are used as outlet controls in the routing. Storage in the pool area is defined by an elevation-storage capacity curve. The hydraulic capacity of the outlet works, spillways, and top of dam are defined by elevation-discharge curves.

Dam overtopping analysis has been conducted by hydrologic methods for this dam and lake. This computation determines the percentage of the PMF hydrograph that the reservoir can contain without the dam being overtopped. An output summary in the hydrologic appendix displays this information as well as other characteristics of the simulated dam overtopping.

The above analysis has been accomplished for this report using the systemized computer program HEC-1 (Dam Safety Version), July, 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. The numeric parameters estimated for this site are listed in the computer printout. Definitions of these variables are contained in the "User's Manual" for the computer program.

The inflow hydrograph was routed through the reservoir using HEC-1's Modified Puls option.

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME LAKE LACAWANNA
I.D. NUMBER 30280
SHEET NO. 1 OF 5
BY OTM DATE 9-25-79

LAKE LACAWANNA

DRAINAGE AREA = 2.8 MI^2 (1,792 ACRES)
FROM U.S.G.S. 7.5-MIN. QUAD.

UNIT HYDROGRAPH PARAMETERS

KIRPICH:

t_c = 0.66 HRS. LAG = 0.6 t_c = 0.40 HRS.
WHERE LENGTH (L) = 12,000 FT.
HEIGHT (H) = 318 FT.

FROM TIME OF CONCENTRATION NOMOGRAPH, KENTUCKY BUREAU OF HIGHWAYS.

CURVE NUMBER METHOD:

$$LAG = \frac{l^{0.8}(S+1)^{0.7}}{1900\ Y^{0.5}} = \frac{(12{,}000)^{0.8}(3.82)^{0.7}}{1900\ (3.0)^{0.5}}$$

$$= \frac{(1834)(2.55)}{3291} = 1.4\ HRS$$

WHERE l = GREATEST FLOW LENGTH IN FEET
$S = \frac{1000}{CN} - 10$ AND CN = S.C.S. CURVE NUMBER
Y = AVERAGE SLOPE

CN = 78, ANTECEDENT MOISTURE CONDITION III
SOIL GROUP "B"

FROM S.C.S.

TIME OF CONCENTRATION USED IN THIS ANALYSIS = 0.66 HRS, LAG = 0.4 HRS.

LOSS RATE AND BASE FLOW

STRTL = 1 INCH
CNSTL = 78 S.C.S. CURVE NO. (AMC III)
STRTQ = 1.5 cfs/mi^2
QRCSN = 0.05 (5% OF PEAK FLOW)
RTIOR = 2.5

PROBABLE MAXIMUM STORM

FROM H.R. NO. 33
P.M.P. INDEX RAINFALL (ZONE 7) = 26.0 INCHES
R_6 = 102 %, R_{12} = 120%, R_{24} = 130 %, R_{48} = 140 %

ELEVATION-AREA-CAPACITY RELATIONSHIP

SPILLWAY CREST ELEV. = 681.5' (FROM FIELD DATA)

FROM THE CONIC METHOD FOR RESERVOIR VOLUME. FLOOD HYDROGRAPH PACKAGE (H.E.C.-1). DAM SAFETY VERSION (USERS MANUAL).

HT. OF DAM = 26.0 (FROM FIELD DATA)

CONSIDER SPILLWAY CREST:
AREA OF NORMAL POOL = 14 AC.
HEIGHT OF POOL = CREST ELEV. - EST. BOTTOM ELEV.
= 681.5 - 662
= 19.5' EST.

FROM: $H = 3V/A$
$V = AH/3$
$= 14(19.5)/3$
$= 91$ ac.ft (ESTIMATED VALUE)

FROM: USGS 7.5-MIN. QUAD.
AT ELEV. 681.5, AREA = 14 AC
AT ELEV. 700, AREA = 34 AC
AT ELEV. 720, AREA = 73 AC

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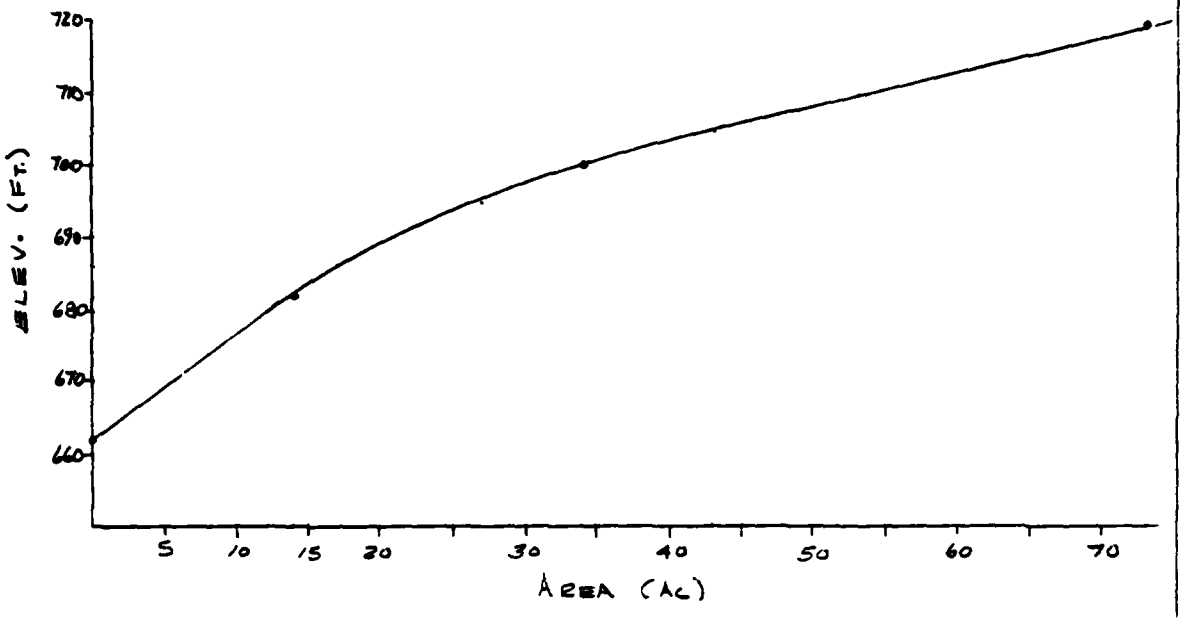
EBENSBURG PENNSYLVANIA

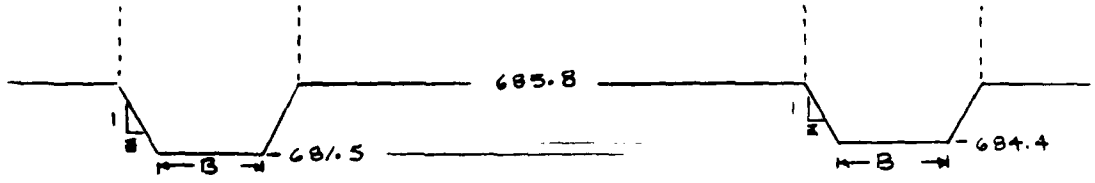
DAM NAME LAKE LACAWANNA
I.D. NUMBER 30280
SHEET NO. 3 OF 5
BY OTM DATE



AREA (AC)	0	14	17.5	21	27	34	43	53	73
ELEV. (FT)	662	681.5	685.8	690	695	700	705	710	720

SPILLWAY DISCHARGE

LEFT SPILLWAY CREST = 681.5'
RIGHT SPILLWAY CREST = 684.4'
} LOOKING DOWNSTREAM



(LEFT SPILLWAY)		(RIGHT SPILLWAY)	
TRAPEZOIDAL	WEIR	TRAPEZOIDAL	WEIR
hp = VARIABLE B = 16' Z = 2.3 C' = 0.95	h = VARIABLE C = 3.1 L = 35.8	hp = VARIABLE B = 13' Z = 2.6 C' = 0.95	h = VARIABLE C = 3.1 L = 20.3

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME LAKE LACAWANNA
I.D. NUMBER 30280
SHEET NO. 4 OF 5
BY OTM DATE

SPILLWAY DISCHARGE CONTINUED;

NOTE: ALL DISCHARGE IS THROUGH TWO TRAPEZODIAL SECTIONS TO ELEVATION 685.8 (TOP OF DAM). AT ELEVATION 685.8 STANDARD WEIR FLOW IS ASSUMED.

FOR TRAPEZOIDAL FLOW:

FROM: $Q = 8.03\, C' h_v^{1/2} (h_p - h_v) [B + z(h_p - h_v)]$

WHERE $h_v = \dfrac{3(2z h_p + B) - (16 z^2 h_p^2 + 16 z B h_p + 9 B^2)^{1/2}}{10 z}$

-LOW DAMS, P-79, NATIONAL RESOURCE COMMITTEE
-WATER AND WASTEWATER ENGINEERING P. 11-34
FAIR, GEYER, AND OKUM

FOR STANDARD WEIR FLOW: $Q = CLH^{3/2}$

ELEV (FT.)	LEFT SPILLWAY				RIGHT SPILLWAY				DISCHARGE Q
	TRAPEZOIDAL		WEIR		TRAPEZOIDAL		WEIR		
	hp (FT.)	Q (cfs)	h (FT.)	Q (cfs)	hp (FT.)	Q (cfs)	h (FT.)	Q (cfs)	NEAREST 10 cfs
681.5	0	0							0
682	0.5	17							20
683	1.5	100							100
684	2.5	230							230
684.4	2.9	300			0	0			300
685	3.5	415			0.6	19			430
685.8	4.3	600	0	0	1.4	75	0	0	670
686	—	—	0.2	10	—	—	0.2	6	690
687			1.2	146			1.2	83	900
688			2.2	362			2.2	205	1240
689			3.2	635			3.2	360	1670
690			4.2	955			4.2	542	2170
691			5.2	1316			5.2	746	2740
692			6.2	1713			6.2	972	3360
693			7.2	2144			7.2	1216	4030
694			8.2	2606			8.2	1478	4760
695			9.2	3097			9.2	1756	5530

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CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME LAKE LACAWANNA
I.D. NUMBER 30280
SHEET NO. 5 OF 5
BY OTM DATE 9-25-79

OVERTOP PARAMETERS

DISCHARGE DETERMINED BY (HEC-1)

TOP OF DAM (LOW SPOT) = 685.8'
LENGTH OF DAM (EXCLUDING SW.) = 464'
COEFFICIENT OF DISCHARGE = 2.9 (BROAD CREST WEIR)
$L_{MAX.}$ = 535' $V_{MAX.}$ = 700'

1/9

```
***********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  26 FEB 79
***********************************

   1            A1      ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
   2            A2      HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF LAKE LACAWANNA DAM
   3            A3      RATIOS OF PMF ROUTED THROUGH THE RESERVOIR (MISSOURI - 30280)
   4            B     288       0      10       0       0       0       0       0       0       0
   5            B1      5
   6            J       1       6       1
   7            J1    .04    .049     .05      .1     .5       1
   8            K       0       1
   9            K1      INFLOW
  10            M       1       2     2.8                       1                       1
  11            P            26.0    10.2     120     130     140
  12            T                                                      -1     -78
  13            W2            0.4
  14            A          W.02     2.5
  15            K       1       2                                       1
  16            K1      ROUTE
  17            Y                               1       1
  18            Y1      1                                         -681.5      -1
  19            Y4  687.8     682     683     684   684.4     685   685.1     686     687     688
  20            Y4    689     690     691     692     693     694     695
  21            Y5      0      20     100     230     300     430     670     690     900    1240
  22            Y5   1670    2170    2740    3360    4030    4760    5530
  23            SA      0      14    17.5      21      27      34      43      53      73
  24            SE    662   681.5   685.8     690     695     700     705     710     720
  25            SS  681.5
  26            SD  685.8     2.9     1.5     464
  27            SL     10      80     120     200     230     318     420     464     500     535
  28            SV  685.8   686.1   686.3   686.7   686.8   687.4   687.5   687.8     690     700
  29            K      99
```

FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79

RUN DATE= 80/02/05.
TIME= 09.03.01.

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF LAKE LACAWANNA DAM
RATIOS OF PMF ROUTED THROUGH THE RESERVOIR (MISSOURI - 302801

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
	0	10	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 6 LRTIO= 1

RTIOS= .04 .05 .05 .10 .50 1.00

B-8

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	2.80	0.00	2.80	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	RT2	R96
0.00	26.00	102.00	120.00	130.00	140.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-78.00	0.00	0.00

CURVE NO = -78.00 WETNESS = -1.00 EFFECT CN = 78.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .40

RECESSION DATA
STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.50

UNIT HYDROGRAPH 14 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .40 VOL= 1.00

682. 2249. 2789. 2229. 1240. 713. 404. 233. 132. 76.
43. 26. 15. 5.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	22200.	7661.	2436.	1250.	360073.
CMS	629.	217.	69.	35.	10196.
INCHES		75.45	32.88	33.23	33.23
MM		646.47	822.89	844.03	844.03
AC-FT		3799.	4833.	4960.	4960.
THOUS CU M		4602.	5961.	6118.	6118.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

B-9

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	888.	306.	97.	50.	14403.
CMS	25.	9.	3.	1.	408.
INCHES		1.02	1.30	1.33	1.33
MM		25.86	32.90	33.76	33.76
AC-FT		152.	193.	196.	198.
THOUS CU M		187.	238.	245.	245.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 2

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1088.	375.	119.	61.	17644.
CMS	31.	11.	4.	2.	500.
INCHES		1.25	1.59	1.63	1.63
MM		31.68	40.30	41.36	41.36
AC-FT		186.	237.	243.	243.
THOUS CU M		230.	292.	300.	300.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 3

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1110.	383.	122.	59.	18004.
CMS	31.	11.	3.	2.	510.
INCHES		1.27	1.62	1.66	1.66
MM		32.32	41.12	42.20	42.20
AC-FT		190.	242.	248.	248.
THOUS CU M		234.	298.	306.	306.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 4

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	8220.	1886.	2486.	125.	360073.
CMS	69.	22.	7.	4.	1020.
INCHES		2.55	4.24	3.32	3.32
MM		64.65	82.24	84.40	84.40
AC-FT		380.	483.	496.	496.
THOUS CU M		469.	596.	612.	612.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 5

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	11100.	3830.	1210.	625.	180037.
CMS	314.	108.	34.	18.	5098.
INCHES		12.73	16.19	16.61	16.61
MM		323.23	411.20	422.01	422.01
AC-FT		1899.	2416.	2480.	2480.
THOUS CU M		2343.	2980.	3059.	3059.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 6

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	22200.	7661.	2436.	1250.	360073.
CMS	629.	217.	69.	35.	10196.
INCHES		25.45	32.38	33.23	33.23
MM		646.47	822.39	844.03	844.03
AC-FT		3799.	4833.	4960.	4960.
THOUS CU M		4686.	5961.	6118.	6118.

HYDROGRAPH ROUTING

ROUTE

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-682.	-1

STAGE	681.00	687.00	688.00	689.00	690.00	691.00	692.00	693.00	694.00	695.00
682.00										
FLOW	0.00	20.00	100.00	230.00	300.00	430.00	670.00	690.00	900.00	
1240.00										
SURFACE AREA=	0.	14.	18.	21.	27.	34.	43.	53.	73.	
CAPACITY=	0.	91.	159.	239.	359.	511.	703.	943.	1570.	
ELEVATION=	682.	687.	688.	690.	693.	700.	705.	710.	720.	

CREL	SPWID	COQW	EXPW	ELEVL	COGL	CAREA	EXPL
681.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
695.8	2.9	1.5	464.

CREST LENGTH	10.	80.	120.	200.	230.	318.	420.	464.	500.	535.
AT OR BELOW ELEVATION	685.8	686.1	686.3	686.7	686.8	687.4	687.5	687.8	690.0	700.0

STATION 2, PLAN 1, RATIO 1

PEAK OUTFLOW IS 518. AT TIME 40.33 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	518.	275.	93.	48.	13709.
CMS	15.	8.	3.	1.	388.
INCHES		.91	1.24	1.27	1.27
MM		23.20	31.45	32.14	32.14
AC-FT		136.	185.	189.	189.
THOUS CU M		168.	228.	233.	233.

STATION 2. PLAN 1. RATIO 2

PEAK OUTFLOW IS 671. AT TIME 40.33 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	671.	341.	115.	59.	16880.
CMS	19.	10.	3.	2.	478.
INCHES		1.15	1.92	1.96	1.96
MM		28.81	48.73	49.57	49.57
AC-FT		169.	228.	233.	233.
THOUS CU M		209.	281.	287.	287.

STATION 2. PLAN 1. RATIO 3

PEAK OUTFLOW IS 678. AT TIME 40.33 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	678.	349.	117.	60.	17293.
CMS	19.	10.	3.	2.	490.
INCHES		1.16	1.96	1.99	1.99
MM		29.43	49.54	50.39	50.39
AC-FT		173.	232.	237.	237.
THOUS CU M		213.	287.	293.	293.

STATION 2. PLAN 1. RATIO 4

PEAK OUTFLOW IS 1966. AT TIME 40.17 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1966.	726.	237.	121.	34901.
CMS	56.	21.	7.	3.	988.
INCHES		2.41	3.15	3.22	3.22
MM		61.24	80.10	81.81	81.81
AC-FT		360.	471.	481.	481.
THOUS CU M		444.	581.	593.	593.

STATION 2, PLAN 1, RATIO 5

PEAK OUTFLOW IS 10885. AT TIME 40.00 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	10885.	3810.	1205.	615.	177253.
CMS	308.	108.	34.	17.	5019.
INCHES		12.66	15.98	16.36	16.36
MM		321.51	405.92	415.49	415.49
AC-FT		1889.	2385.	2442.	2442.
THOUS CU M		2330.	2942.	3012.	3012.

STATION 2, PLAN 1, RATIO 6

PEAK OUTFLOW IS 21959. AT TIME 40.00 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	21959.	7646.	2413.	1236.	355998.
CMS	622.	217.	68.	35.	10081.
INCHES		25.40	32.07	32.85	32.85
MM		645.21	814.60	834.47	834.47
AC-FT		3791.	4787.	4904.	4904.
THOUS CU M		4677.	5904.	6048.	6048.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .04	RATIO 2 .05	RATIO 3 .05	RATIO 4 .10	RATIO 5 .50	RATIO 6 1.00
HYDROGRAPH AT	1	2.80	1	888.	1088.	1110.	2220.	11100.	22200.
		7.25)		25.15((	30.80((	31.43((	62.86((	314.32((	628.64((
ROUTED TO	2	2.80	1	518.	671.	678.	1966.	10885.	21959.
		7.25)		14.68((	19.00((	19.19((	55.66((	308.24((	621.81((

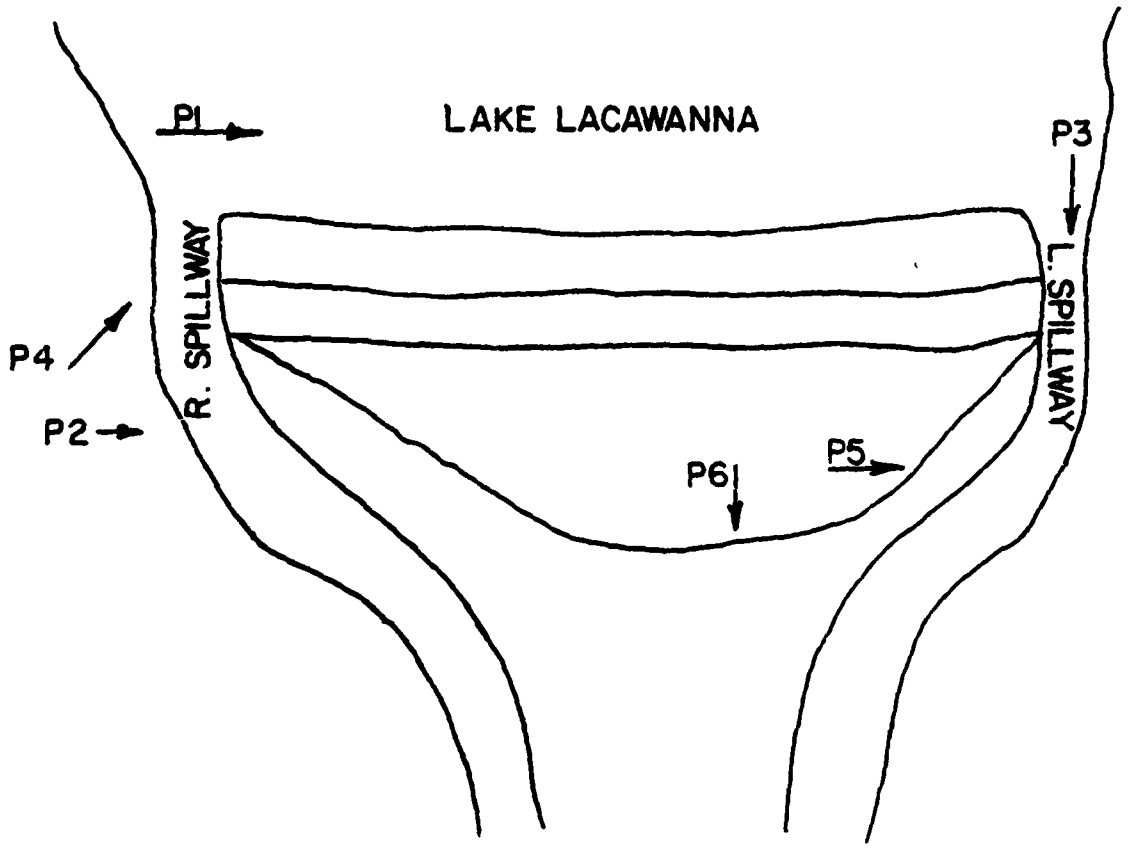
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ..... INITIAL VALUE SPILLWAY CREST TOP OF DAM

ELEVATION	681.50	681.50	685.80
STORAGE	71.	71.	159.
OUTFLOW	0.	0.	670.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.04	685.29	0.00	156.	518.	0.00	40.33	0.00
.05	685.81	.01	159.	671.	.17	40.33	0.00
.05	685.87	.07	160.	678.	.33	40.33	0.00
.10	687.41	1.61	188.	1966.	2.50	40.17	0.00
.50	690.08	4.28	251.	10869.	7.17	40.00	0.00
1.00	692.17	6.37	286.	21550.	13.33	40.00	0.00

PHOTOGRAPHS



-INDICATES PHOTO LOCATION

LAKE LACAWANNA DAM
PHOTO INDEX

Photograph No. 3

Left spillway looking downstream.

Photograph No. 4

Right spillway looking upstream.

Photograph No. 5

Left spillway exit channel.

Photograph No. 6
Seepage exiting from beyond downstream toe.